ELECTRICAL ENGINEERING DESIGN CRITERIA

1.0 INTRODUCTION

This section describes the design criteria which will be used for all electrical work related to this project.

2.0 DESIGN CODES AND STANDARDS

The design and specification of all work shall be in accordance with all applicable laws and regulations of the Federal Government and the State of California, and applicable local codes and ordinances. A listing of the codes and industry standards to be used in design and construction follows:

- California State Building Code
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society (IES)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- Occupational Safety and Health Act (OSHA)
- Underwriters Laboratories Inc (UL)

Other recognized standards will be used as required to serve as design, fabrication, and construction guidelines when not in conflict with the above-listed standards.

The codes and industry standards used for design, fabrication, and construction will be the codes and industry standards, including all addenda, in effect as stated in equipment and construction purchase or contract documents.

3.0 ELECTRIC MOTORS

3.1 General Motor Design Criteria

These paragraphs outline basic motor design guide parameters for selection and purchase of electric motors.

The following design parameters shall be considered:

- Environment
- Voltage utilization and phases
- Frequency
- Horsepower and starting requirements and limitations
- Motor type (synchronous, induction, dc, etc) and construction
- Power factor
- Service factor
- Speed and direction of rotation
- Insulation
- Temperature limitations of winding insulation and enclosures
- Duty cycle time
- Accessory devices
- Enclosure
- Bearing construction, rating life of rolling elements, and external lube oil system for sleeve or plate bearings
- Cooling requirements

- Ambient noise level and noise level for motor and driven equipment
- Frame size
- Termination provisions for power, grounding, and accessories
- Installation, testing, and maintenance requirements
- Special features (shaft grounding, temperature and vibration monitoring, etc)

3.1.1 Codes and Standards

All motors will be designed, manufactured, and tested in accordance with the latest applicable standards, codes, and technical definitions of ANSI, IEEE, NEMA, and ABMA, and where supplemented by requirements of the specifications.

3.1.2 Electrical Design Criteria

Special requirements for individual motors and specifications for special application motors are to be included in individual specification technical sections and will have precedence over these general motor requirements.

3.1.2.1 Rating

The motor nameplate horsepower multiplied by the motor nameplate service factor will be at least 10 percent greater than the driven equipment operating range maximum brake horsepower.

Motor operating voltages (excluding motor-operated valves) are tabulated below:

Horsepower	Nominal System Voltage	Motor Nameplate Voltage	Frequency Hz	Phases
Less than 3/4	120	115	60	1
Greater than or equal to 3/4 and less than or equal to 250 (except for special applications)	480	460	60	3
Greater than 250	4160	4000	60	3

Horsepower	Nominal System Voltage	Motor Nameplate Voltage	Frequency Hz	Phases
Dc motors	125	120	dc	--

This table is intended as a general guide; however, individual conditions such as distance from power source, voltage drop, motor availability, and cost may dictate deviations from the stated horsepower/voltage criteria.

Motors will be designed for full voltage starting and frequent starting where required and will be suitable for continuous duty in the specified ambient conditions. Intermittent-duty motors will be selected where recognized and defined as standard by the equipment standards and codes.

The torque characteristics of all induction motors will be as required to accelerate the inertia loads of the motor and driven equipment to full speed without damage to the motor or the equipment at any voltage from 90 percent to 110 percent of motor nameplate voltage except those to be individually considered. A voltage drop greater than 10 percent from the specified motor nameplate rating will be individually considered for proper motor starting and operating.

3.1.2.2 Allowable Noise

The motor sound level will conform with the motor driven equipment assembly overall sound level requirements. In no case will the average no-load sound pressure level, reference level 20 micropascals, produced by the motor exceed 85 dBA free field at 1 meter for motors rated 200 horsepower and less, and at 2 meters for motors rated above 200 horsepower.

3.1.2.3 Temperature Considerations

Integral horsepower motors will be designed for an ambient temperature of 40° C. Motors located in areas where the ambient temperature exceeds 40° C will be designed for that ambient condition.

3.1.2.4 Windings and Insulation

All insulated windings will have Class B nonhygroscopic insulation systems rated for temperature rise and ambient temperature in accordance with NEMA MG 1 standards. When ambient temperatures greater than 40 C are specified, the allowable temperature rise will be reduced in accordance with NEMA MG 1 standards.

Motors rated 460V and lower will have Class B or Class F insulation systems. Motors rated above 460V shall have Class F insulation systems. Motors furnished with Class F insulation will have temperature rise in accordance with NEMA MG 1 values for Class B insulation.

All insulated stator winding conductors and wound-rotor motor secondary windings will be copper.

Sealed insulation for formed-coil windings will be in accordance with the requirements of NEMA MG 1 standards.

The insulation resistance corrected to 40 C will be not less than motor rated kV+1 megohms for all windings.

Where required, the windings will be treated with a resilient, abrasion resistant material.

3.1.2.5 Space Heaters

Space heaters will be furnished for all motors 25 hp and larger. Space heaters will be sized as required to maintain the motor internal temperature above the dew point when the motor is idle. Motor space heaters will not cause winding temperatures to exceed rated limiting values nor cause thermal protective device over temperature indication when the motor is not energized.

Where required above, 460 volt motors space heaters shall 120 volt, single-phase, 60 hertz. All 4000 volt motors will have space heaters. Space heaters rated 1,200 watts and less will be suitable for operation on 120 volts, single-phase, 60 hertz. Heaters rated above 1,200 watts will be suitable for operation on 208 volts, 3-phase, 60 hertz.

Space heaters will be either replaceable metal sheathed type or fixed flexible silastic wraparound type. Heaters will be located and insulated so they do not damage motor components or finish.

Space heater leads will be stranded copper cable with 600 volt insulation and shall include terminal connectors. Space heater leads will be wired to a separate terminal housing on 4000 volt motors.

3.1.2.6 Nameplates

All motor nameplate data will conform to NEMA MG 1-20.60 requirements.

3.2 4000 Volt Motors

3.2.1 Design and Construction

Design and construction of 4000 volt motors will be coordinated with the driven equipment requirements.

All motor power lead terminal housings will be adequately sized to terminate the power conductors. For 4000 volt motors, the power lead terminal housing will also be large enough to provide working space for field fabrication of stress cones within the housing in addition to containing the stress cones after installation. The terminal housing of motors 1,500 horsepower and larger will also have sufficient room to accommodate current transformers and neutral connections.

Separate terminal housings will be provided for the following:

- Motor power leads
- Motor accessory leads
- Motor temperature detector leads

All leads will be wired into their respective terminal housings.

Motor enclosures will normally be fully guarded, open dripproof for indoor service, and weather protected NEMA Type II for outdoor service.

3.2.2 Bearings

All horizontal motors will be provided with sleeve bearings unless required otherwise.

On vertical motors, antifriction or plate type thrust bearings will be furnished, and antifriction type guide bearings will be furnished. Whenever a plate type thrust bearing is required, it shall be a Kingsbury self-adjusting type.

Grease or oil lubricated antifriction bearings will be designed and fabricated in accordance with ABMA standards to have a minimum L-l0 rating life of not less than 100,000 hours under the load, speed, and thrust requirements for direct coupled service and not less than 17,500 hours for belt or chain connected service.

3.2.3 Temperature Detectors

Bearing temperature detectors, complete with detector head and holder assemblies as required, will be furnished on motors with sleeve bearings when specified on the Motor Specification and Data Sheets.

Winding temperature detectors will be furnished, installed, and wired complete when specified on the Motor Specification and Data Sheets.

3.3 460 Volt Integral Horsepower Motors

3.3.1 Design and Construction

Design and construction of each 460 volt integral horsepower motor will be coordinated with the driven equipment requirements and the requirements of NEMA MG 1 Standards.

Motors will normally have TEFC enclosures.

3.3.2 Bearings

For horizontal motors, antifriction bearings will be provided for NEMA frame size 449 and below, and sleeve bearings will be provided above NEMA frame size 449.

For vertical motors, antifriction or plate type thrust bearings and antifriction type guide bearings will be furnished. Whenever a plate type thrust bearing is required, it shall be of the Kingsbury self-adjusting type.

Grease lubricated or oil lubricated antifriction radial and thrust bearings will be designed and fabricated in accordance with ABMA standards to have a minimum L-10 rating life of not less than 100,000 hours under the load, speed, and thrust requirements for direct coupled service and not less than 17,500 hours for belt or chain connected service.

3.4 Direct Current Machines

All direct current machines will be designed and constructed for continuous operation and in accordance with the requirements of NEMA MG 1.

3.5 Fractional Horsepower Motors

Type, design, and construction of each general, special, and definite purpose fractional horsepower motor will be coordinated with the driven equipment requirements and will be in accordance with the requirements of NEMA MG 1.

3.6 Motor Operators for Nonmodulating Valve, Gate, or Damper Service

Motors will be designed for high torque, reversing service in a 50° C ambient temperature and will be in accordance with the requirements of NEMA MG 1 and MG 2.

3.6.1 Bearings

Antifriction bearings having an ABMA minimum L-10 rating life of not less than 15,000 hours will be furnished.

3.6.2 Space Heaters

All motor operators will be supplied with 120 volt ac, single-phase space heaters located in the limit switch compartment and in the motor.

3.7 Hoist, HVAC, and Miscellaneous Motors

Motors not related to power production will conform to applicable requirements of NEMA MG 1 and will otherwise be manufacturer’s standard.

4.0 POWER AND CONTROL WIRING

4.1 Design Conditions

Cable feeders from 13.8 kV and 4.16 kV power equipment will be sized so that a short-circuit fault at the terminals of the load will not result in damage to the cable prior to normal operation of fault interrupting devices.

Single conductor cables for service above 2 kV will be shielded, thereby accomplishing the following results:

- Confinement of the dielectric field within the cable
- Obtaining a symmetrical radial distribution of voltage stress within the dielectric
- Compliance with ICEA recommendations for shielding
- Reducing the hazard of shock to personnel
- Allowing circuits to be dc high potential tested after installation

Instrument cable will be shielded to minimize electrical noise attenuation as follows:

- Aluminum-polyester tape and copper drain wire will be used for shielding.
- Low level analog signal cables will be made up of twisted and shielded pairs.
- Digital signal cables will be twisted and shielded pairs.

- Except where specific reasons dictate otherwise, cable shields will be electrically continuous. When two lengths of shielded cable are connected together at a terminal block, a point on the terminal block will be used for connecting the shields.

- For multipair cables using individual pair shields, the shields will be electrically isolated from each other.

To be effective, instrument cable shields should be grounded on one end as follows:

- The shield on instrument circuits will typically be grounded at the power supply end, unless dictated otherwise by the control equipment supplier.

- The shields on grounded as well as ungrounded thermocouple circuits will be grounded at the thermocouple well, unless dictated otherwise by the control equipment supplier.

- Multipair cables used with thermocouples will have individually isolated shields so that each shield will be maintained at the particular thermocouple ground potential.

- Each RTD (resistance temperature detector) system, consisting of one power supply and one or more RTDs, will be grounded at only one point.

- RTDs embedded in windings of transformers and rotating machines will be grounded at the frame of the respective equipment. The shields will also be grounded at the equipment, unless dictated otherwise by the control equipment supplier.

- The low or negative potential side of a signal pair will be grounded at the same point where the shield is grounded. Where a common power supply is used, the low side of each signal pair and its shield will be grounded at the power supply.

4.2 Conductors

All current carrying conductors, except for thermocouple wiring, will be copper.

The maximum ampacity for any cable will depend upon the worst case in which the cable will be routed (tray, conduit, duct, or direct buried). In addition to ampacity, special requirements such as voltage drop and available fault current will be taken into consideration in the sizing of cable.

The allowable ampacity of power cables will be in accordance with NEC requirements.

4.3 Cable Constructions

Cable insulation and construction will be as follows.

4.3.1 Flame Retardance

To minimize the damage that can be caused by a fire, insulated conductors installed in cable tray shall have nonpropagating and self-extinguishing characteristics. These cables shall meet the flame test requirements of IEEE 383, using a 70,000 Btu/h gas burner flame source.

4.3.2 Medium Voltage Power Cable

Single conductor shielded power cable, with stranded copper conductor, cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) insulation, and flame retardant polyvinyl chloride (FRPVC), flame retardant chlorinated polyethylene (CPE), or flame retardant chlorosulfonated polyethylene (CSP) jacket will be used on service above 2400 volts. The insulation level versus service voltage will be as follows:

Service Voltage	Insulation Level
13.8 kV grounded	15 kV 133 percent
4.16 kV grounded	5 kV 133 percent

4.3.3 600 Volt Power Cable

Cable with 600 volt rated thermosetting insulation will be used to feed 600 volt ac, 125 volt dc power loads, and 600 volt ac motor loads.

Loads requiring 3-phase, 12 to 2 AWG conductors will be fed with NEC type TC power cable which utilizes three insulated copper conductors, XLPE or EPR insulation, a bare ground wire, and an FRPVC, CPE, or CSP overall jacket.

Loads requiring 1 AWG and larger conductors will be fed with single conductor power cable which uses stranded copper conductor, XLPE or EPR insulation without an overall jacket.

These cables may be routed in trays, conduits, or ducts.

4.3.4 600 Volt Control Cable

Cable with 600 volt rated insulation will be used in 120 volt ac and all dc control, metering, and relaying applications.

Direct current circuits, which are routed underground, shall utilize multiple conductor control cable having 10, 12, or 14 AWG stranded copper conductors, XLPE or EPR insulation, and with an FRPVC, CPE, or CSP overall jacket.

Direct current circuits which are routed aboveground, and all 120 volt ac circuits, will utilize the same construction as below grade dc circuits, as stated above, or may utilize multiple conductor control cable having 10, 12, or 14 AWG stranded copper conductors, NEC Type TC with THHN or THWN (PVC/nylon) insulated conductors, and with an FRPVC overall jacket.

The conductor size for current transformer circuits will be 10 AWG or larger.

Cables may be routed in trays, conduits, or ducts with the constructions indicated.

4.3.5 600 Volt Instrument Cable

Instrument cable will be used for circuits that require shielding to avoid induced currents and voltages. Cables may be routed in trays, conduits, or ducts and will be routed separate from 480 volt power circuits. The following cable constructions will be utilized:

- 600 volt, single pair and single triad shielded instrument cable, 16 AWG stranded copper conductors, XLPE or EPR insulation, FRPVC, CPE, or CSP jacket overall

- 600 volt multiple pair, shielded instrument cable with individually shielded pairs and overall shield, 16 AWG stranded copper conductors, XLPE or EPR insulation, FRPVC, CPE, or CSP jacket overall

4.3.6 Thermocouple Extension Cable

Thermocouple extension cable will be used for extension leads from thermocouples to junction boxes and to instruments for measurements of temperature. Cables may be routed in trays, conduits, or ducts. The following cable construction will be utilized:

- 600 volt, single pair, solid alloy conductor with the same material as the thermocouples, with shield over each pair (except for one pair construction) and with an overall shield, l6 AWG XLPE or EPR insulation; FRPVC, CPE, or CSP jacket overall

4.3.7 High Temperature Cable

High temperature cable will be used for wiring to devices located in areas with ambient temperatures above 75° C. Cables may be routed in conduit. Cable lengths will be minimized by terminating the cable at terminal boxes or conduit outlet fittings located outside the high temperature area and continuing the circuit with control or thermocouple extension cable. The following cable construction will be used:

- Single-conductor control cable; NEC Type SF-2 12 AWG; stranded copper conductor; silicone rubber insulation; braided glass jacket

- Single pair shielded thermocouple extension cable; solid alloy conductor with the same material as the thermocouples; 16 AWG; FEP teflon insulation; FEP teflon jacket overall

4.3.8 Lighting and Fixture Cable

Lighting and fixture cable with 600 volt insulation will be used as follows:

- NEC Type XHHW with copper conductor for 120 volt circuits in outdoor or unheated areas or 208 volt circuits in all areas All circuit runs totally in conduit

- Circuit runs for roadway or outdoor area lighting enclosed in PVC duct, stranded copper conductors, NEC Type XHHW conductor insulation

- Fixture wire, NEC Type SF-2, with copper conductor, silicone rubber insulation, braided glass jacket

Lighting and fixture cable designations and conductor sizes will be identified on the drawings. Minimum conductor size will be 12 AWG.

4.3.9 Grounding Cable

Grounding cable will be NEC Type THW or THHN insulated and uninsulated copper conductors sized as required.

4.3.10 Switchboard and Panelboard Cable

Switchboard and panelboard cable will be insulated for 600 volts with flame retardant XLPE or EPR moisture resistant insulation.

4.3.11 Special Cable

This type of cable will include cable supplied with equipment, prefabricated cable, coaxial cable, communication cable, etc. This cable will normally be supplied by a particular manufacturer.

Special cable will be routed in accordance with manufacturer's recommendations.

4.3.12 Miscellaneous Cable

If other types and construction of cable are required as design and construction of the unit progress, they will be designated and routed as required.

4.4 Testing Requirements

Testing of installed cable will be performed by the Construction Contractor in accordance with the contract requirements.

4.5 Installation

Cable installation will be performed by the Construction Contractor in accordance with the contract requirements.

4.6 Connectors

All cable connector requirements will be specified by Black & Veatch and provided by the Construction Contractor.

5.0 PROTECTIVE RELAYING

The selection and application of protective relays are discussed in the following paragraphs. These relays protect equipment in the Auxiliary Power Supply System, Generator Terminal System, Primary Power Supply System, Turbine Generator System, and the electrical loads powered from these systems.

The following general requirements apply to all protective relay applications:

- The protective relaying scheme will be designed to remove or alarm abnormal occurrences on equipment designed for electrical power generation, voltage transformation, energy conversion, and transmission and distribution of electrical power.
- The protective relaying scheme will also achieve the following:
  - Limit damage to faulted equipment.
  - Minimize possibility of fire or explosion.
  - Minimize hazards to personnel.
- The protective relaying system will be a coordinated application of individual relays. For each monitored abnormal condition, there will exist a designated primary device for detection of that condition. A failure of any primary relay will result in the action of a secondary overlapping scheme to detect the effect of the same abnormal occurrence. The secondary relay may be the primary relay for a different abnormal condition. Alternate relays may exist which detect the initial abnormal condition but which have an inherent time delay so that the alternate relays will operate after the primary and secondary relays. Similar to secondary relays, the alternate relays may be primary relays for other abnormal conditions. All protective relays will be selected to coordinate with protective devices supplied by manufacturers of major items and the thermal limits of electrical equipment, such as transformers and motors. Where selective coordination cannot be achieved, protection will be maintained.

- Secondary current produced by current transformers will be in the 5 ampere range, and voltage signals produced by potential transformers will be in the 120 volt range.

5.1 Generator Protective Relays

A protective relay and monitoring system, including generator differential protection, will be provided to minimize the effects from generator faults and malfunctions and will be interfaced with the utility's protection scheme.

Protective relaying and monitoring will be selected to provide, as a minimum, detection and corrective/isolation action as required for faults and malfunctions.

5.2 Power Transformer Relays

5.2.1 Generator *S*tep-up Transformer

The generator step-up transformer is protected against the effects of the following conditions:

- Phase faults
- Ground faults
- Sudden pressure
- Excessive tank pressure
- Combustible gas
- Oil level
- High temperature
- Excessive volts per hertz (Protection is from the volts per hertz relay used with the generator.)

5.3 Metal-Clad Switchgear

A summary of the protective functions used in the 4160 volt metal-clad switchgear lineups is discussed in the following paragraphs. The relays for the auxiliary electrical protective relay system will be selected and set to provide coordinated tripping to mitigate the faulted connection.

5.3.1 Bus and Incoming (Source) Breakers and/or High Voltage Contractors

Each incoming (source) breaker and/or contactor will be provided with protective relay type devices. These devices may be single element type or multifunction relays. The incoming breakers and/or contactors and bus will be provided with devices to detect and take appropriate action against the effects of the following conditions:

- Phase faults
- Ground faults
- Overloads
- Undervoltage

Each medium voltage switchgear bus will be provided with two undervoltage relays (Device 27) which will, when bus voltage drops to a preset level, trip load feeder circuit breakers.

5.3.2 Remote Switchgear Feeder(s)

Each remote switchgear feeder will be provided with protective devices to detect and take appropriate action against the effects of the following conditions:

- Phase faults
- Ground faults
- Overloads

5.3.3 Secondary Unit Substation Feeder(s)

Auxiliary transformers, including the excitation transformer, shall be supplied from NEMA Class E2 fused motor starters. Each secondary unit substation transformer will be provided with protective devices, consisting of GE Mulitlin, or equivalent, relays, to detect and take appropriate action against the effects of the following conditions:

- Phase faults
- Ground faults
- Overloads

5.3.4 Motor Feeder(s)

Medium voltage motors will be supplied from NEMA Class E2 fused motor starters. Each motor feeder will be provided with protective devices, consisting of GE Mulitlin protective relays, to detect and take appropriate action against the effects of the following conditions:

- Phase faults
- Ground faults
- Overloads

5.4 480 Volt Secondary Unit Substations

Overload and phase-to-phase fault protection for loads connected to the 480 volt secondary unit substations (SUS) will be provided by solid-state trip devices (SSTD) which are an integral part of the drawout type air circuit breakers.

Breakers supplying motors of other devices which do not require coordination with downstream trip devices will have adjustable long-time and instantaneous elements for phase protection.

Main breakers, tie breakers, and breakers supplying motor control centers (MCC) or other loads which contain trip devices will have adjustable long-time and short-time SSTD elements for phase protection. The pickup point and time settings will be adjustable to allow for proper coordination with all downstream trip devices.

Ground fault detection will be provided.

5.4.1 480 Volt Motor Control Centers

Each magnetic starter within an MCC which supplies power to a motor will be equipped with a magnetic-only molded case circuit breaker and thermal overload protection in the starter to protect motors against overload.

Certain loads will be fed from MCC feeder circuit breakers. The breakers will be thermal magnetic molded case breakers sized to protect supply cable and individual loads.

5.4.2 480 Volt Power Panels

Power panels will be supplied with thermal-magnetic circuit breakers sized to protect supply cable and individual loads.

6.0 CLASSIFICATION OF HAZARDOUS AREAS

Areas where flammable and combustible liquids, gases, and dusts are handled and stored will be classified for the purpose of determining the minimum criteria for design and installation of electrical equipment to minimize the possibility of ignition. The criteria for determining the appropriate classification are specified in Article 500 of the National Electrical Code (NFPA 70). The application of these criteria to specific areas at generating stations is provided in the following subsections and in Article 127 of the National Electrical Safety Code (ANSI C2).

In addition to defining hazardous areas by class and division, each hazardous element is also assigned a group classification (A, B, C, etc.). The group classifications of hazardous elements are specified in Article 500 of the National Electrical Code and in NFPA Standard 497M.

Electrical equipment in areas classified as hazardous will be constructed and installed in accordance with the requirements of Articles 501 and 502 of the National Electrical Code.

References for use in classification of areas, as well as specification of requirements for electrical installation in such areas, include the following:

- National Electrical Safety Code, ANSI C2
- National Electrical Code, NFPA 70/ANSI C1
- National Fire Codes, and National Fire Protection Association codes, standards, and recommendations
- American Petroleum Institute Recommended Practices
- American Gas Association, Publication XFO277

6.1 Flammable and Combustible Liquid Storage and Handling

Areas where flammable and combustible liquids are stored and handled will be classified as indicated in the following subsections.

6.1.1 Flammable Liquids

Flammable liquids (flash point below 100° F/38° C), which include gasoline (Group D hazard), will be considered hazardous wherever they are handled or stored. The areas where gasoline is handled or stored will be classified as specified in Section 127.E of the National Electrical Safety Code.

6.1.2 Combustible Liquids

Combustible liquids (flash point of 100° F/38° C or higher) include fuel oil, diesel fuel, and lubrication oil (Group D hazards). Areas where these liquids are handled or stored will not be classified because they will not be handled or stored at temperatures which will produce sufficient vapors to form an ignitable mixture with air beyond the surface of the liquid within the piping or vessel in which they are normally contained.

6.2 Gaseous Hydrogen Systems

(Not Applicable.)

6.3 Natural Gas Systems

Natural gas systems used as a fuel source for combustion turbine generators will be classified as follows. Classification of areas within the combustion turbine equipment is as follows:

- Outdoor areas within 5 feet (1.5 m) of vents from relief valves will be Class I, Division 1, Group D. The area from 5 feet (1.5 m) to 15 feet (4.5 m) from the vent will be classified as Class I, Division 2, Group D.
- Enclosed areas which are adequately ventilated and contain equipment such as gas compressors, valves, regulators, etc., where natural gas will be present outside of the contained equipment only upon equipment failure will be classified Class I, Division 2, Group D. An area extending 5 feet (1.5 m) from the ridge vents for such enclosures shall also be classified Class I, Division 2, Group D.
- Outdoor areas within 15 feet (4.5 m) of gas compressors, regulators, valves, etc., will be classified Class I, Division 2, Group D.
- Enclosed areas which are not adequately ventilated and where bleed gas or gas leakage is anticipated will be classified Class I, Division 1, Group D. Adequately ventilated areas within 10 feet (3 m) of these enclosures, unless separated by a vaportight barrier, will be classified as Class I, Division 2, Group D. Areas separated by a vaportight barrier will be classified as nonhazardous.
- Enclosed areas which are adequately ventilated and contain equipment such as valves, pipe flanges, instruments, screwed pipe connections, etc., where natural gas will be present outside of the contained equipment only upon equipment failure, and which contain natural gas detectors which shut off the supply of natural gas outside the enclosed area, will be classified as nonhazardous except for within 15 feet (4.5 m) of the valve, flange, instrument, or screwed connection (potential source of gas), which shall be classified as Class I, Division 2, Group D.
- Indoor areas such as burner fronts where flames, heat, or other such sources of ignition are present will not be classified as hazardous.
- The use of low-pressure natural gas for building heating systems will not in itself be considered a cause for classifying an adequately ventilated area as hazardous.

6.4 Liquid Hydrogen Systems

(Not Applicable.)

6.5 Sewage Lift Stations

Sewage lift station wet wells and any enclosed nonventilated area above the wet well will be classified Class I, Division 1, Group D.

7.0 GROUNDING

The station grounding system will be an interconnected network of bare copper conductor and copper-clad ground rods. The system will be provided to protect plant personnel and equipment from the hazards which can occur during power system faults, and to provide the ability to detect line-to-ground faults.

7.1 Design Basis

The station grounding grid will be designed for adequate capacity to dissipate heat from ground current under the most severe conditions in areas of high ground fault current concentrations, with grid spacing so that safe voltage gradients are maintained.

Bare conductors to be installed below grade will be spaced in a grid pattern to be indicated on the construction drawings. Each junction of the grid will be bonded together by an exothermal welding process.

In the plant area, grounding stingers will be connected to selected equipment. The grounding system will be extended, by way of stingers and conductors installed in raceway, to the remaining plant equipment. Equipment grounds will conform to the following general guidelines:

- Grounds will conform to the NEC and NESC.
- Major items of equipment, such as switchgear, secondary unit substations, motor control centers, relay panels, and control panels, will be connected to the station ground grid.

- Electronic panels and equipment, where required, will be grounded using an insulated ground wire connected in accordance with the manufacturer's recommendations.
- Distributed control system cabinets and equipment will be grounded according to manufacturer's requirements or recommendations.
- Motor supply circuits to 480 volt motors, which utilize three-conductor cable with a ground in the interstices, will utilize this ground for the motor ground. For 480 volt motor supply circuits which use three single-conductor cables, the ground conductor will be sized in accordance with the applicable codes.
- All 2300 volt and higher voltage rated motors will have a minimum of one 4/0 AWG bare copper ground conductor connected between the motor frame and the station ground grid.
- A copper grounding conductor will be routed parallel to all power conductors operating above 208/120 volts in accordance with the applicable codes.
- All ground wires installed in conduit will be insulated.

Remote buildings and outlying areas with electrical equipment will be grounded by establishing local subgrade ground grids and equipment grounding systems in a manner similar to the plant area. Remote grids, where practical, will be interconnected with the station ground grid.

7.2 Materials

Grounding materials will be as follows:

- Rods will be copper-clad.
- Cable will be soft-drawn copper with Class B stranding or copper-clad steel.
- Exothermal welds will use molds, cartridges, and materials as manufactured by Cadweld or equivalent.
- Clamps, connectors, and other hardware used with the grounding system will be made of copper.
- Ground wires installed in conduit will be soft-drawn copper with Class B stranding, and green colored 600 volt PVC insulation.

8.0 LIGHTING

The lighting system will provide personnel with illumination of plant equipment and roads under normal conditions. The power supply for the lighting system will be from 208/120 volt, 3-phase, four-wire panelboards located in the unit and BOP 480V distribution switchgear.

8.1 Light Sources

The lighting system will be designed in accordance with the Illuminating Engineering Society (IES) to provide illumination levels recommended by the following standards and organizations:

- ANSI/IES RP-8, Roadway Lighting
- Design Guide for GE and Black & Veatch

Table 8-1 summarizes the illumination levels.

Table 8-1
Illumination Levels

Location	Maintained Foot-Candles	Illumination LUX
Outdoor Catwalks and Platforms	2	20
Roadway		
Between or along buildings	1	10
Not bordered by buildings	0.5	5

Light sources and fixture selections will be based on the applicability of the luminaries for the area under consideration.

Generally, high-pressure sodium lamps will be used outdoors.

For design purposes, lighting is categorized by the following areas:

- Outdoor areas

- Roadway and area

8.2 Outdoor Areas

This category includes lighting of equipment located outdoors and outdoor platforms. High-pressure sodium fixtures suitable for use in wet locations will be used.

8.3 Roadway and Area

Roadway and perimeter fence lighting will be designed using high-pressure sodium light sources. The light fixtures will be installed on tapered steel poles.

8.4 Lighting Control

Electric power to light fixtures located outdoors will be switched with photo-electric controllers.

8.5 Wiring Devices

Convenience outlets located outdoors will be provided with weatherproof snap-action covers. In hazardous locations, convenience outlets will be suitable for the NEC class and group requirements.

9.0 FREEZE PROTECTION

(Not Applicable.)

10.0 LIGHTNING PROTECTION

(Not Applicable.)

11.0 RACEWAY AND CONDUIT

The design and specifications for the raceway and conduit systems used in supporting and protecting electrical cable will be in accordance with the provisions of the NEC.

11.1 Cable Tray

All cable trays will be of trough or ladder type construction with a maximum rung spacing of 9 inches, nominal depths of 4 to 6 inches, and various widths as required. There will be a maximum spacing of 8 feet between cable tray supports, except fittings (elbows, tees, etc.) which shall be supported in accordance with NEMA standards.

Cable tray fittings will have a radius equal to or greater than the minimum bending radius of the cables they contain.

Individual tray systems will be established for the following services:

- Medium voltage power cables
- 480 volt power cables equal to or greater than 2/0 AWG
- 120 volt ac, 125 volt dc, and 24 volt dc power, control, and multiconductor 480 volt power cables
- Special noise sensitive circuits or instrument cables

Further division will be provided where required by the equipment manufacturer.

The summation of the cross-sectional areas of cable in tray will generally be limited to 50 percent for control and instrument cables, and in accordance with the NEC for power cables.

The minimum design vertical spacing for trays will be 9 inches measured from the bottom of the upper tray to the top of the lower tray. At least a 9 inch clearance will also be maintained between the top of a tray and beams, piping, or other obstacles, to facilitate installation of cables in the tray. A working space of not less than 24 inches will be maintained on at least one side of each tray.

Ventilated covers will be provided for vertical trays. Solid covers will be provided for all solid bottom tray. Solid covers will also be provided for the top tray of horizontal tray runs located under grating floor or insulated piping.

11.2 Conduit

Conduit will be used to protect conductors to individual devices, in hazardous areas, and where the quantity of cable does not economically justify the use of cable tray.

PVC conduit will be used for duct banks and for some below grade concrete encased conduit.

Liquidtight flexible metallic conduit will be used for connections to accessory devices such as solenoid valves, limit switches, pressure switches, etc., for connections to motors or other vibrating equipment, and across areas where expansion or movement of the conduit is required.

All other conduit, unless specific environmental requirements dictate the use of plastic or aluminum conduit, will be rigid galvanized steel.

Exposed conduit will be routed parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical conduit bends or fittings.

Conduit will be sized in accordance with the National Electrical Code.

Conduit will be securely supported within 3 feet of connections to boxes and cabinet and in accordance with the following:

Conduit Size	Maximum Distance Between Supports
1/2 up to 1-1/2 inch	8 feet
1-1/2 inch and larger	10 feet

11.3 Duct Banks

Underground duct banks will be used for cable routed between buildings and other remote areas as necessary.

All underground duct banks will consist of Type EB plastic conduit encased in concrete. Galvanized steel conduits will also be installed where required for digital and analog low-level circuits requiring noise immunity from adjacent power circuits.

Duct bank risers and conduit from manholes to the equipment at remote locations will be changed to rigid steel prior to emerging from below grade. All below grade conduit will be encased in concrete.

Ducts will be sloped to manholes to provide adequate drainage. Low spots in duct runs will be avoided.

Concrete manholes, handholes, and vaults will be provided, where required, so that cable may be installed without exceeding allowable pulling tensions and cable sidewall pressures. Each manhole will have the following provisions:

- Provisions for attachment of cable pulling devices
- Provisions for racking of cables
- Manhole covers of sufficient size to loop feed the largest diameter cable through the manhole without splicing
- Sealed bottoms
- Water stops at duct bank entrances